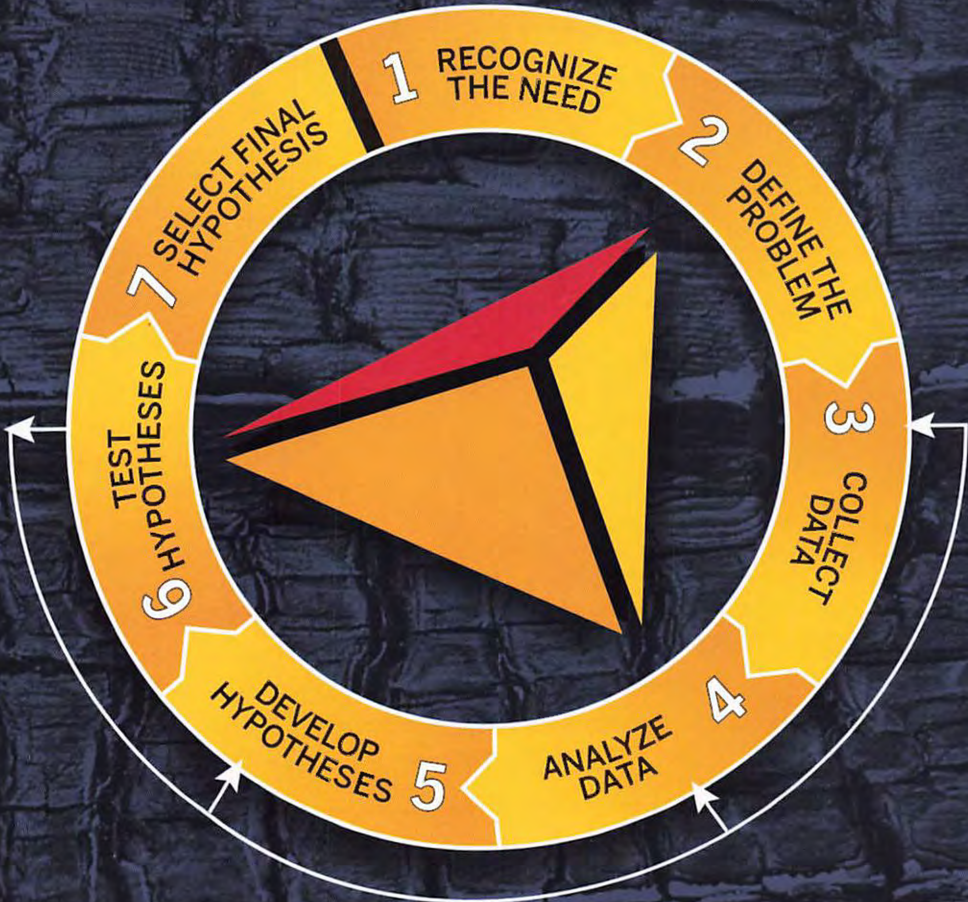
EXHIBIT 12

NFPA® 921

Guide for Fire and Explosion Investigations

2021



only nonmandatory provisions using the word "should" to indicate recommendations in the body of the text.

3.2.5* Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the *NFPA Manual of Style.* When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Absolute Temperature. A temperature measured in Kelvins (K) or Rankines (R).

3.3.2 Accelerant. A fuel or oxidizer, often an ignitible liquid, intentionally used to initiate a fire or increase the rate of growth or spread of fire.

3.3.3 Accident. An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an unexpected happening due to carelessness, ignorance, and the like.

3.3.4 Active Fire Protection System. A system that uses moving mechanical or electrical parts to achieve a fire protection goal. [**3,** 2018]

3.3.5 Ambient. Someone's or something's surroundings, especially as they pertain to the local environment; for example, ambient air and ambient temperature.

3.3.6 Ampacity. The maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating. [**70,** Article 100]

3.3.7 Ampere. The unit of electric current that is equivalent to a flow of one coulomb per second; one coulomb is defined as 6.24×10^{18} electrons.

3.3.8 Arc. A high-temperature luminous electric discharge across a gap or through a medium such as charred insulation.

3.3.9 Arc Mapping. Identifying and documenting a fire pattern derived from the identification of arc sites used to aid in determining the area of fire origin or spread.

N **3.3.10 Arc Melting.** Melting of conductors and conducting surfaces as a result of electrical arcing. The characteristics of arc melting are described in 9.11.1.1.

3.3.11 Arc Site. The location on a conductor with localized damage that resulted from an electrical arc.

3.3.12 Arcing Through Char. Arcing associated with a matrix of charred material (e.g., charred conductor insulation) that acts as a semiconductive medium.

3.3.13 Area of Origin. A structure, part of a structure, or general geographic location within a fire scene, in which the "*point of origin*" of a fire or explosion is reasonably believed to be located. *(See also 3.3.149, Point of Origin.)*

3.3.14 Arrow Pattern. A fire pattern displayed on the cross-section of a burned wooden structural member.

3.3.15 Arson. The crime of maliciously and intentionally, or recklessly, starting a fire or causing an explosion.

3.3.16 Autoignition. Initiation of combustion by heat but without a spark or flame.

3.3.17 Autoignition Temperature. The lowest temperature at which a combustible material ignites in air without a spark or flame.

3.3.18 Backdraft. A deflagration resulting from the sudden introduction of air into a confined space containing oxygen-deficient products of incomplete combustion.

3.3.19 Bead. A rounded mass of resolidified metal on the end of the remains of an electrical conductor or conductors that was caused by arcing and is characterized by a sharp line of demarcation between the melted and unmelted conductor surfaces.

3.3.20 Blast Pressure Front. The expanding leading edge of an explosion reaction that separates a major difference in pressure between normal ambient pressure ahead of the front and potentially damaging high pressure at and behind the front.

3.3.21 BLEVE. Boiling liquid expanding vapor explosion.

3.3.22 Bonding. The permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to conduct safely any current likely to be imposed.

3.3.23 British Thermal Unit (Btu). The quantity of heat required to raise the temperature of one pound of water 1°F at the pressure of 1 atmosphere and temperature of 60°F; a British thermal unit is equal to 1055 joules, 1.055 kilojoules, and 252.15 calories.

3.3.24 Burning Rate. See 3.3.110, Heat Release Rate (HRR).

3.3.25* Calcination of Gypsum. A fire effect realized in gypsum products, including wallboard, as a result of exposure to heat that drives off free and chemically bound water.

3.3.26 Calorie. The amount of heat necessary to raise 1 gram of water 1°C at the pressure of 1 atmosphere and temperature of 15°C; a calorie is 4.184 joules, and there are 252.15 calories in a British thermal unit (Btu).

Δ **3.3.27 Cause.** The circumstances, conditions, or agencies that brought about or resulted in the fire or explosion incident, damage to property, bodily injury, or loss of life.

3.3.28 Ceiling Jet. A relatively thin layer of flowing hot gases that develops under a horizontal surface (e.g., ceiling) as a result of plume impingement and the flowing gas being forced to move horizontally.

3.3.29 Char. Carbonaceous material that has been burned or pyrolyzed and has a blackened appearance.

3.3.30 Char Blisters. Convex segments of carbonized material separated by cracks or crevasses that form on the surface of char, forming on materials such as wood as the result of pyrolysis or burning.

Δ **3.3.31 Clean Burn.** A distinct and visible fire effect generally apparent on noncombustible surfaces after combustible layer(s) (such as soot, paint, and paper) have been burned away.

3.3.206 Ventilation. The movement of gases within, into, or from any compartment or space or the firefighting operation of removing smoke and heat from the structure by opening windows and doors or making holes in the roof.

3.3.207 Ventilation-Controlled Fire. A fire in which the heat release rate or growth is controlled by the amount of air available to the fire.

3.3.208 Venting. The escape of smoke and heat through openings in a building.

3.3.209 Volt (V). The unit of electrical pressure (electromotive force) represented by the symbol "E"; the difference in potential required to make a current of one ampere flow through a resistance of one ohm.

3.3.210 Watt (W). Unit of power, or rate of work, equal to one joule per second, or the rate of work represented by a current of one ampere under the potential of one volt.

3.3.211 Work Plans. An outline of the tasks to be completed as part of the investigation including the order or timeline for completion. See Chapter 15, Planning the Investigation.

N **3.4* Canine Definitions.** Deploying canine-handler teams in fire investigations requires the investigator to understand certain concepts that are described by specialized terminology. This section provides definitions of terms used in relation to the canine section *(see Section 17.7)*.

N **3.4.1 Canine-Handler Team.** A canine-handler team is a human and working dog who train and work together as an operational unit. [SC1, 2011]

N **3.4.2* Certification.** Certification is the recognition that a canine-handler team has acquired and demonstrated specialized knowledge, skills, and abilities in the standard practices necessary to execute the duties of a canine team. Certification also provides the fire investigator a means of identifying those canine-handler teams that have successfully demonstrated compliance with established requirements. In addition, certification establishes that a canine-handler team achieves and maintains proficiency.

N **3.4.3 Handler.** The handler is a person who has successfully completed a documented training and certification process in canine handling in the specific discipline of ignitible liquid canine detection and maintains those abilities through field application, maintenance training, scheduled recertification, and continuing education. *(See 3.4.2, Certification.)* [SC1, 2011].

N **3.4.4* Ignitible Liquid Detection Canines (IGL Canines).** Ignitible liquid detection canines (IGL canines) are dogs specifically trained to locate and respond to the presence of certain classes of ignitible liquids by associated odor.

N **3.4.5* Scent Discrimination.** Operational usage: A dog's olfactory ability to distinguish between various odors.

Chapter 4 Basic Methodology

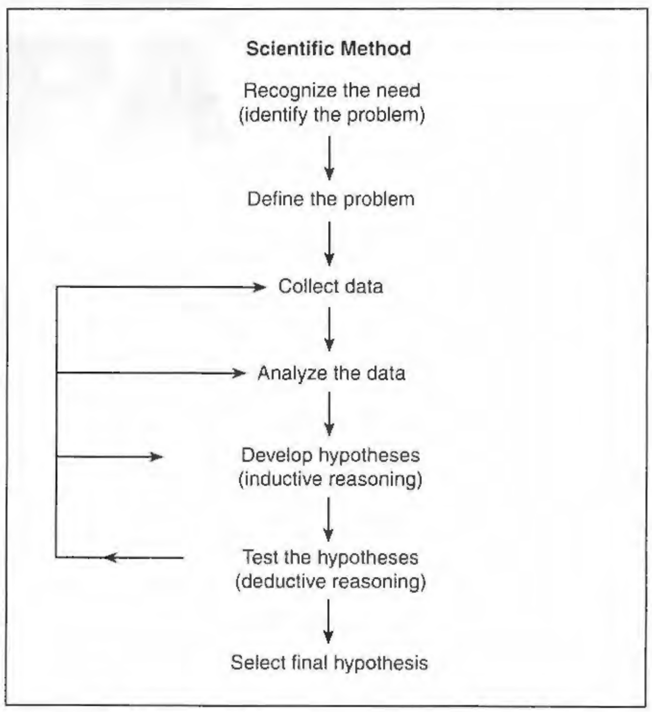
4.1* Nature of Fire Investigations. A fire or explosion investigation is a complex endeavor involving skill, technology, knowledge, and science. The compilation of factual data, as well as an analysis of those facts, should be accomplished objectively, truthfully, and without expectation bias, preconception, or prejudice. The basic methodology of the fire investigation should rely on the use of a systematic approach and attention to all relevant details. The use of a systematic approach often will uncover new factual data for analysis, which may require previous conclusions to be reevaluated. With few exceptions, the proper methodology for a fire or explosion investigation is to first determine and establish the origin(s), then investigate the cause: circumstances, conditions, or agencies that brought the ignition source, fuel, and oxidant together.

4.2 Systematic Approach. The systematic approach recommended is based on the scientific method, which is used in the physical sciences. This method provides an organizational and analytical process that is desirable and necessary in a successful fire investigation.

4.3 Relating Fire Investigation to the Scientific Method. The scientific method *(see Figure 4.3)* is a principle of inquiry that forms a basis for legitimate scientific and engineering processes, including fire incident investigation. It is applied using the following steps outlined in 4.3.1 through 4.3.10.

4.3.1 Recognize the Need. First, one should determine that a problem exists. In this case, a fire or explosion has occurred and the cause should be determined and listed so that future, similar incidents can be prevented.

4.3.2 Define the Problem. Having determined that a problem exists, the investigator or analyst should define the manner in which the problem can be solved. In this case, a proper origin and cause investigation should be conducted. This is done by an examination of the scene and by a combination of other data collection methods, such as the review of previously conducted investigations of the incident, the interviewing of witnesses or other knowledgeable persons, and the results of scientific testing.



Δ **FIGURE 4.3 Use of the Scientific Method.**

4.3.3 Collect Data. Information about the fire or explosion incident is now collected by observation, experiment, or other direct data-gathering means. The data collected is called empirical data because it is based on observation or experience and is capable of being verified or known to be true.

4.3.4* Analyze the Data. The scientific method requires that all data collected be analyzed. This is an essential step that must take place before the formation of the final hypothesis. The identification, gathering, and cataloging of data does not equate to data analysis. Analysis of the data is based on the knowledge, training, experience, and expertise of the individual doing the analysis. If the investigator lacks expertise to properly attribute meaning to a piece of data, then assistance should be sought. Understanding the meaning of the data will enable the investigator to form hypotheses based on the evidence, rather than on speculation.

4.3.5* Develop Hypotheses (Inductive Reasoning). Based on the data analysis, the investigator produces hypotheses to explain the phenomena, whether it be the nature of fire patterns, fire spread, identification of the origin, the ignition sequence, the fire cause, or the causes of damage or responsibility for the fire or explosion incident. This process is referred to as inductive reasoning. These hypotheses should be based solely on the empirical data that the investigator has collected through observation and then developed into explanations for the event, which are based upon the investigator's knowledge, training, experience, and expertise.

4.3.6* Test the Hypotheses (Deductive Reasoning). The investigator does not have a valid or reliable conclusion unless the hypothesis can stand the test of careful and serious challenge. Testing of the hypothesis is done by the principle of deductive reasoning, in which the investigator compares the hypothesis to all known facts as well as the body of scientific knowledge associated with the phenomena relevant to the specific incident. Testing of a hypothesis should be designed to disprove, or refute, the hypothesis. This may also be referred to as falsification of the hypothesis. Working to disprove a hypothesis is an attempt to find all the data or reasons why the hypothesis is not supported or not true, rather than simply finding and relying on data that support the hypothesis or why the hypothesis is true. This method of testing the hypothesis can prevent "confirmation bias," which can occur when the hypothesis or conclusion relies only on supporting data *(see 4.3.10)*. A hypothesis can be tested physically by conducting experiments, analytically by applying accepted scientific principles, or by referring to scientific research. When relying on the research of others, the investigator or analyst must ensure that the conditions, circumstances, and variables of the research and those of the hypothesis are sufficiently similar. Whenever the investigator relies on research as a means of hypothesis testing, references to the research relied upon should be acknowledged and cited. If the hypothesis is refuted or not supported, it should be discarded and alternate hypotheses should be developed and tested. This may require the collection of new data or the reanalysis of existing data. The testing process needs to be continued until all feasible hypotheses have been tested and one is determined to be uniquely consistent with the facts and with the principles of science. If no hypothesis can withstand an examination by deductive reasoning, the issue should be considered undetermined.

4.3.6.1* Any hypothesis that is incapable of being tested either physically or analytically, is an invalid hypothesis. A hypothesis developed based on the absence of data is an example of a hypothesis that is incapable of being tested. The inability to refute a hypothesis does not mean that the hypothesis is true.

4.3.7 Select Final Hypothesis. The final step in applying the scientific method is to select the final hypothesis. Once the hypothesis has been tested, the investigator should review the entire process to ensure that all credible data are accounted for and all feasible alternate hypotheses have been considered and eliminated. When using the scientific method, the failure to consider alternate hypotheses is a serious error. A critical question to be answered is, "Are there any other hypotheses that are consistent with the data?" The investigator should document the facts that support the final hypothesis to the exclusion of all other reasonable hypotheses.

4.3.8 Avoid Presumption. Until data have been collected, no specific hypothesis can be reasonably formed or tested. All investigations of fire and explosion incidents should be approached by the investigator without presumption as to origin, ignition sequence, cause, fire spread, or responsibility for the incident until the use of the scientific method has yielded testable hypotheses, which cannot be disproved by rigorous testing.

4.3.9 Expectation Bias. Expectation bias is a well-established phenomenon that occurs in scientific analysis when investigator(s) reach a premature conclusion without having examined or considered all of the relevant data. Instead of collecting and examining all of the data in a logical and unbiased manner to reach a scientifically reliable conclusion, the investigator(s) uses the premature determination to dictate investigative processes, analyses, and, ultimately, conclusions, in a way that is not scientifically valid. The introduction of expectation bias into the investigation results in the use of only that data that supports this previously formed conclusion and often results in the misinterpretation and/or the discarding of data that does not support the original opinion. Investigators are strongly cautioned to avoid expectation bias through proper use of the scientific method.

4.3.10* Confirmation Bias. Different hypotheses may be compatible with the same data. When using the scientific method, testing of hypotheses should be designed to disprove a hypothesis (i.e., falsification of the hypothesis), rather than relying only on confirming data that support the hypothesis. Confirmation bias occurs when the investigator relies exclusively on data that supports the hypothesis and fails to look for, ignores, or dismisses contradictory or nonsupporting data. The same data may support alternate and even opposing hypotheses. The failure to consider alternate or opposing hypotheses, or prematurely discounting seemingly contradictory data without appropriate analysis and testing can result in incorrect conclusions. A hypothesis can be said to be valid only when rigorous testing has failed to disprove the hypothesis. Disproving the hypothesis is a process in which all the evidence is compared against the proffered hypothesis in an effort to find why the hypothesis is not true.

4.4 Basic Method of a Fire Investigation. Using the scientific method in most fire or explosion incidents should involve the steps shown in 4.4.1 through 4.4.6.

4.4.1 Receiving the Assignment. The investigator should be notified of the incident, told what his or her role will be, and told what he or she is to accomplish. For example, the investigator should know if he or she is expected to determine the

origin, cause, and responsibility; produce a written or oral report; prepare for criminal or civil litigation; make suggestions for code enforcement, code promulgation, or changes; make suggestions to manufacturers, industry associations, or government agency action; or determine some other results.

4.4.2 Preparing for the Investigation. The investigator should marshal his or her forces and resources and plan the conduct of the investigation. Preplanning at this stage can greatly increase the efficiency and therefore the chances for success of the overall investigation. Estimating what tools, equipment, and personnel (both laborers and experts) will be needed can make the initial scene investigation, as well as subsequent investigative examinations and analyses, go more smoothly and be more productive.

4.4.3 Conducting the Investigation.

4.4.3.1 It is during this stage of the investigation that an examination of the incident fire or explosion scene is conducted. The fundamental purpose of conducting an examination of any incident scene is to collect all of the available data and document the incident scene. The investigator should conduct an examination of the scene if it is available and collect data necessary to the analysis.

4.4.3.2 The actual investigation may include different steps and procedures, which will be determined by the purpose of the assignment. These steps and procedures are described in detail elsewhere in the document. A fire or explosion investigation may include all or some of the following tasks: a scene inspection or review of previous scene documentation done by others; scene documentation through photography and diagramming; evidence recognition, documentation, and preservation; witness interviews; review and analysis of the investigations of others; and identification and collection of data from other appropriate sources.

4.4.3.3 In any incident scene investigation, it is necessary for at least one individual/organization to conduct an examination of the incident scene for the purpose of data collection and documentation. While it is preferable that all subsequent investigators have the opportunity to conduct an independent examination of the incident scene, in practice, not every scene is available at the time of the assignment. The use of previously collected data from a properly documented scene can be used successfully in an analysis of the incident to reach valid conclusions through the appropriate use of the scientific method. Thus, the reliance on previously collected data and scene documentation should not be inherently considered a limitation in the ability to successfully investigate the incident.

4.4.3.4 The goal of all investigators is to arrive at accurate determinations related to the origin, cause, fire spread, and responsibility for the incident. Improper scene documentation can impair the opportunity of other interested parties to obtain the same evidentiary value from the data. This potential impairment underscores the importance of performing comprehensive scene documentation and data collection.

4.4.4 Collecting and Preserving Evidence. Valuable physical evidence should be recognized, documented, properly collected, and preserved for further testing and evaluation or courtroom presentation.

4.4.5 Analyzing the Incident. All collected and available data should be analyzed using the principles of the scientific method. Depending on the nature and scope of one's assignment, hypotheses should be developed and tested explaining the origin, ignition sequence, fire spread, fire cause or causes of damage or casualties, or responsibility for the incident.

4.4.6 Conclusions. Conclusions, which are final hypotheses, are drawn as a result of testing the hypotheses. Conclusions should be drawn according to the principles expressed in this guide and reported appropriately.

4.5 Level of Certainty. The level of certainty describes how strongly someone holds an opinion (conclusion). Someone may hold any opinion to a higher or lower level of certainty. That level is determined by assessing the investigator's confidence in the data, in the analysis of that data, and testing of hypotheses formed. That level of certainty may determine the practical application of the opinion, especially in legal proceedings.

4.5.1 The investigator should know the level of certainty that is required for providing expert opinions. Two levels of certainty commonly used are probable and possible:

(1) Probable. This level of certainty corresponds to being more likely true than not. At this level of certainty, the likelihood of the hypothesis being true is greater than 50 percent.
(2) Possible. At this level of certainty, the hypothesis can be demonstrated to be feasible but cannot be declared probable. If two or more hypotheses are equally likely, then the level of certainty must be "possible."

4.5.2 If the level of certainty of an opinion is merely "suspected," the opinion does not qualify as an expert opinion. If the level of certainty is only "possible," the opinion should be specifically expressed as "possible." Only when the level of certainty is considered "probable" should an opinion be expressed with reasonable certainty.

4.5.3 Expert Opinions. Many courts have set a threshold of certainty for the investigator to be able to render opinions in court, such as "proven to an acceptable level of certainty," "a reasonable degree of scientific and engineering certainty," or "reasonable degree of certainty within my profession." While these terms of art may be important for the specific jurisdiction or court in which they apply, defining these terms in those contexts is beyond the scope of this document.

4.6 Review Procedure. A review of a fire investigator's work product (e.g., reports, documentation, notes, diagrams, photos, etc.) by other persons may be helpful, but there are certain limitations. This section describes the types of reviews and their appropriate uses and limitations.

4.6.1 Administrative Review. An administrative review is one typically carried out within an organization to ensure that the investigator's work product meets the organization's quality assurance requirements. An administrative reviewer will determine whether all of the steps outlined in an organization's procedure manual, or required by agency policy, have been followed and whether all of the appropriate documentation is present in the file, and may check for typographical or grammatical errors.

4.6.1.1 Limitations of Administrative Reviews. An administrative reviewer may not necessarily possess all of the knowledge, skills, and abilities of the investigator or of a technical reviewer. As such, the administrative reviewer may not be able to provide a substantive critique of the investigator's work product.

that area. Some systems provide only alarm or water flow data, and do not specify a particular zone. This information can be helpful in comparing the time of system activation to the time and observations of first arriving fire fighters or other witness, in assessment of the growth and spread of the fire.

18.3.3.12 Security Cameras. Security cameras that monitor buildings or ATMs may be very useful, particularly for providing "hard" times *(see the discussion of timelines in Chapter 24).* Events before or during the fire including, in some cases, the actual ignition and development of the fire may have been recorded. The video recorder may be found in a secure area or a remote location. It should be recovered and reviewed even if damaged.

18.3.3.13 Intrusion Alarm Systems. An intrusion system may activate during a fire due to heat, smoke movement, the destruction of wiring, or loss of power. A monitored intrusion system may send a trouble signal to the monitoring station if a transmission line is compromised or power is lost. As with fire alarm systems, attempts should be made to recover the alarm panel history before the alarm system is reset. This frequently requires special expertise. Some alarm systems may record the identity of persons entering and leaving the building.

18.3.3.14 Witness Observations. Observations by witnesses are data that can be used in the context of determining the origin. Such witnesses can provide knowledge of conditions prior to, during, and after the fire event. Witnesses may be able to provide photographs or videotapes of the scene before or during the fire. Observations are not necessarily limited to visual observations. Sounds, smells, and perceptions of heat may shed light on the origin. Witness statements regarding the location of the origin create a need for the fire investigator to conduct as thorough an investigation as possible to collect data that can support or refute the witness statements. When witness statements are not supported by the investigator's interpretation of the physical evidence, the investigator should evaluate each separately.

18.4 Analyze the Data. The scientific method requires that all data collected that bears upon the origin be analyzed. This is an essential step that must take place before the formation of any hypotheses. The identification, gathering, and cataloging of data does not equate to data analysis. Analysis of the data is based on the knowledge, training, experience, and expertise of the individual doing the analysis. If the investigator lacks the knowledge to properly attribute meaning to a piece of data, then assistance should be sought from someone with the necessary knowledge. Understanding the meaning of the data will enable the investigator to form hypotheses based on the evidence, rather than on speculation or subjective belief.

18.4.1 Fire Pattern Analysis. An investigator should read and understand the concepts of fire effects, fire dynamics, and fire pattern development described in Chapters 5 and 6. This knowledge is essential in the analysis of a scene to determine the origin of the fire.

18.4.1.1 Consideration of All Patterns. All observed patterns should be considered in the analysis. Accurate determination of the origin of a fire by a single dominant fire pattern is rare, as in the case of very limited fire damage where there may be only one fire pattern.

18.4.1.2 Sequence of Patterns. While fire patterns may be the most readily available data for origin determination, the investigator should keep in mind that the damage and burn patterns observed after a fire represent the total history of the fire. A major challenge in the analysis of fire pattern data is to determine the sequence of pattern formation. Patterns observed in fires that are extinguished early in their development can present different data than those remaining after full room involvement or significant building destruction. Patterns generated as a result of a rekindle may impact the perception of the fire's history or sequence of pattern production.

18.4.1.3 Pattern Generation. The investigator should not assume that the fire at the origin burned the longest and therefore fire patterns showing the greatest damage must be at the area of origin. Greater damage in one place than in another may be the result of differences in thermal exposure due to differences in fuel loading, the location of the fuel package in the compartment, increased ventilation, or fire-fighting tactics. For similar reasons, a fire investigator should consider these factors when there is a possibility of multiple origins.

18.4.1.3.1 The size, location, and heat release rate of a fuel package may have as much effect on the extent of damage as the length of time the fuel package was burning. An area of extensive damage may simply mean that there was a significant fuel package at that location. The investigator should consider whether the fire at such a location might have spread there from another location where the fuel load was smaller.

18.4.1.3.2 Fuel packages of identical composition and equal size may burn very differently, depending on their location in a compartment. The possible effect of the location of walls relative to the fire should be considered in interpreting the extent of damage as it relates to fire origin. In making the determination, the possibility that the fuel in the suspected area of origin was not the first material ignited and that the great degree of damage was the result of wall or corner effects should be considered.

18.4.1.4 Ventilation. Ventilation, or lack thereof, during a fire has a significant impact on the heat release rate and consequently on the extent of observable burn damage. The analysis of fire pattern data should, therefore, include consideration that ventilation influenced the production of the pattern. Ventilation-controlled fires tend to burn more intensely near open windows or other vents, thereby producing greater damage. Knowledge of the location and type of fuel is important in fire pattern analysis. During full room involvement conditions, the development of fire patterns is significantly influenced by ventilation. Full room involvement conditions can cause fire patterns that developed during the earlier fuel-controlled phase of the fire to evolve and change. In addition, fires can produce unburned hydrocarbons that can be driven outside the compartment through ventilation openings. This unburned fuel can mix with air and burn on the exterior of the compartment, producing additional fire patterns that indicate the fire spread out of the original compartment. Thus, knowledge of changes in ventilation (e.g., forced ventilation from building systems, window breakage, opening or closing of doors, burn-through of compartment boundaries) is important to understand in the context of fire pattern analysis. Determination of what patterns were produced at the point of origin by the first item ignited usually becomes more difficult as the size and duration of the fire increases. This is especially true if the compartment has achieved full room involvement.

18.4.1.5 Movement and Intensity Patterns. As discussed in Chapter 6, fire patterns are generated by one of two mecha-

purchase, such as new or used, how and when they were used, repair history, and problems should also be gathered.

19.3.4* Identify the Oxidant. The most common oxidant (oxidizer or oxidizing agent) within a fire is the oxygen in earth's atmosphere, and no special documentation is required. However, other oxidants, as described in 19.3.4.1 through 19.3.4.3, should be identified and documented when they are in or near the area of origin.

19.3.4.1 Sometimes oxygen exists at greater than the normal atmospheric concentration, such as in hyperbaric chambers, in oxygen tents, or around oxygen generation, concentration, and storage equipment.

19.3.4.2 Some chemicals other than molecular oxygen are classified as oxidants. Certain common chemicals, such as pool sanitizers, may also act as oxidants.

19.3.4.3 Some chemical mixtures, such as solid rocket fuel, contain an oxidizer as well as a fuel and require no external oxidizing source.

19.3.5 Identify Ignition Sequence Data. The investigator should collect data that can be used to analyze the events that brought the fuel and ignition source together (ignition sequence). This information on the conditions surrounding the coincidence of fuel, ignition source, and oxidizer may be available through observations, witness accounts, or weather data. Time lines can be useful in organizing and analyzing this data. *(See Chapter 21.)* Additional data collection may be necessary in order to determine the circumstances that brought the fuel, ignition source, and oxidizer together. Data collection may continue even after the fire scene has been processed and could require specialized laboratory equipment. Such additional data may result in modification or rejection of previously developed hypotheses or reconsideration of previous rejected hypotheses.

Δ **19.4 Analyze the Data.** The scientific method requires that all data collected be analyzed. Analyzing the data requires the examination and interpretation of each component of data collected for its role in the fire cause. This is an essential step that must take place in the formation of any hypotheses. The purpose of the analysis is to attribute specific meaning to the results of the examination and interpretation process, which will ultimately play a role in hypothesis development and testing. The identification, gathering, and cataloging of data does not equate to data analysis. Analysis of the data is based on the knowledge, training, experience, and expertise of the individual doing the analysis. If the investigator lacks the knowledge to properly attribute meaning to a piece of data, then assistance should be sought from someone with the necessary knowledge. Understanding the meaning of the data will enable the investigator to form hypotheses based on the evidence, rather than on speculation or subjective belief.

19.4.1 Fuel Analysis. Fuel analysis is the process of identifying the first (initial) fuel item or package that sustains combustion beyond the ignition source and identifying subsequent target fuels beyond the first fuel ignited.

19.4.1.1 Geometry and Orientation. An understanding of the geometry and orientation of the fuel is important in determining if the fuel was the first material ignited. The physical configuration of the fuel plays a significant role in its ability to be ignited. A nongaseous fuel with a high surface-to-mass ratio is much more readily ignitible than a fuel with a low surface-to-mass ratio. Examples of high surface-to-mass fuels include dusts, fibers, and paper. As the surface-to-mass ratio increases, the heat energy or time required to ignite the fuel decreases. Gases and vapors are fully dispersed (in effect, an extremely high surface-to-mass ratio) and can be ignited by a low heat energy source instantly.

19.4.1.2 Ignition Temperature. The fuel must be capable of being ignited by the hypothesized ignition source. The ignition temperature of the fuel should be understood. It is important to understand the difference between piloted ignition and autoignition temperatures. The components in most buildings are not susceptible to ignition by heat sources of low energy, low temperature, or short duration. For example, flooring, structural lumber, wood cabinets, and carpeting do not ignite unless they are exposed to a substantial heat source.

19.4.1.3 Quantity of Fuel. The first material ignited may not result in fire growth and spread if a sufficient quantity of the fuel does not exist. For example, if the lighter fluid used to start a charcoal fire is consumed before enough heat is transferred to the briquettes, the fire goes out. The investigator should conduct an analysis of the quantity of fuels (primary, secondary, tertiary, etc.) to determine that it is sufficient to explain the resulting fire.

Δ **19.4.2 Ignition Source Analysis.** The investigator should evaluate all potential ignition sources in the area of origin to determine if they are competent. A competent ignition source will have sufficient energy and be capable of transferring that energy to the fuel long enough to raise the fuel to ignition.

19.4.2.1 Heating of the potential fuel will occur by the energy that reaches it. Each fuel reacts differently to the energy that impacts on it based upon its thermal and physical properties. Energy can be reflected, transmitted, or dispersed through the material, with only the absorbed energy causing the fuel temperature to rise.

19.4.2.2 Flammable gases or liquid vapors, such as those from gasoline, may travel a considerable distance from their original point of release before reaching a competent ignition source. Only under specific conditions will ignition take place, the most important condition being concentration within the flammable limits and an ignition source of sufficient energy located in the flammable mixture.

19.4.3 Oxidant. The oxidant is usually the oxygen in the atmosphere. In some cases alternate or additional oxidants may have been present, and the investigator should consider this and the role of such conditions in ignition and spread.

Δ **19.4.3.1** If the existence of an oxidant other than atmospheric oxygen is suspected based upon the presence of residue, that residue should be collected and analyzed in a laboratory. Typically the oxidant does not survive in its original form but may leave characteristic residues.

19.4.4 Ignition Sequence.

19.4.4.1 The ignition sequence of a fire event is defined as the succession of events and conditions that allow the source of ignition, the fuel, and the oxidant to interact in the appropriate quantities and circumstance for combustion to begin. Simply identifying a fuel or an ignition source by itself does not and cannot describe how a fire came to be. Fire results from the interaction of fuel, an oxidant, and an ignition source. Therefore, the investigator should be cautious about deciding